Dynamical Properties of a Heisenberg Ferrofluid: Theory and Molecular Dynamics

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One of the simplest models of a disordered continuous system exhibiting ferromagnetic behavior is a fluid with an isotropic Heisenberg-like spin interaction [1]. Because of its simplicity, the theoretical study of static and dynamical properties for this model is especially interesting [2] and, in comparison with results of computer simulations, could be considered as a test for any theory developed for an inhomogeneous fluid Recently, the first evidence of a ferromagnetic phase in a undercooled liquid metal Co_{80} Pd_{20} was found [3].

We report the results obtained by molecular dynamics (MD) for hydrodynamic time correlation functions of a Heisenberg ferrofluid at several thermodynamic points. The MD simulations were performed on the basis of a new algorithm based on Suzuki-Trotter-like decompositions of the Liouville operator. Contrary to existing integrating schemes [4], the algorithm proposed can be applied not only for lattice models but to continuous spin systems as well. The MD results are compared with theoretical predictions [1,5] for the hydrodynamic collective mode spectrum, transport coefficients as well as for hydrodynamic time correlation functions of a Heisenberg model ferrofluid, obtained in the hydrodynamic regime within microscopic statistical treatment. The generalization of the theory for range of fixed values of wavenumber κ and frequency ω is discussed. We also consider the conditions for observation of spin propagating waves in the `spin density—spin density' time correlation function, when the system is in a paramagnetic state.

This study is supported by the Fonds für Förderung der wissenschaftlichen Forschung (Project P 12422 TPH).

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